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The effects of music exposure and own genre preference on conscious and unconscious cognitive processes: A pilot ERP study

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Abstract

Did Beethoven and Mozart have more in common with each other than Clapton and Hendrix? The current research demonstrated the widely reported *Mozart Effect* as only partly significant. Event-related brain potentials (ERPs) were recorded from 16 professional classical and rock musicians during a standard 2 stimulus visual oddball task, while listening to classical and rock music. During the oddball task participants were required to discriminate between an infrequent target stimulus randomly embedded in a train of repetitive background or standard stimuli. Consistent with previous research, the P3 and N2 ERPs were elicited in response to the infrequent target stimuli. Own genre preference resulted in a reduction in amplitude of the P3 for classical musicians exposed to classical music and rock musicians exposed to rock music. Notably, at the pre-attentive stage of processing (N2) beneficial effects of exposure to classical music were observed for both groups of musicians. These data are discussed in terms of short and long-term music benefits on both conscious and unconscious cognitive processes.

Keywords: Music; Cognition; Classical; Contemporary; Event-related potential (ERP); P3; N2; Pre-attention; Preference; Mozart; Familiarity

1. Introduction

In 1993 a key article presented in *Nature* suggested that listening to classical music facilitates cognitive performance (Rauscher, Shaw, & Ky, 1993). The so-called *Mozart Effect* (ME) was demonstrated as spatial reasoning performance was enhanced following 10 min exposure to the Mozart sonata in D for two pianos (K. 448). Whilst several studies claim to have replicated the original research, using a variety of classical pieces including works by Schubert (Rideout, Dougherty, & Wernert, 1998) and Bach (Ivanov & Geake, 2003), others remain sceptical (Chabris, 1999; Bridgett & Cuevas, 2000; Steele, Ball, & Runk, 1997). For example,

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Chabris (1999) carried out a meta-analytic review of the literature and suggested *enjoyment arousal* as a more probable mechanism for the ME. Rather than Mozart *per se*, music may be one of many enjoyable stimuli that increases arousal or mood with subsequent non-music benefits. Consequently, it remains unclear whether the so-called ME exists and whether or not it can be generalised across music genre (e.g. rock music).

Rauscher and colleagues (1993) findings have resulted in significant debate which centres on two accounts of potential non-music benefits of classical music exposure. The first view proposes that specific qualities of classical music facilitate cognition. This account is consistent with the Trion model of cortical organisation, which suggests neural firing patterns accompanying music activity share similarities with other higher cognitive functions (Leng & Shaw, 1991). This proposal mirrors the literature regarding priming, since music might stimulate neural circuitry which prepares the brain for higher cognitive functioning. Similarly, in terms of long term music benefits, music training has been found to impact on the neural structure supporting cognitive function. For example, Ho, Cheung, and Chan (2003) found that music training during childhood mediates development of the left temporal lobe leading to increased verbal memory ability. Together these findings suggest that music directly influences the structure and functioning of the human brain.

Much research favours an alternative account related to music enjoyment, arousal and mood. Investigations of mood and arousal during music exposure have indicated increased physiological activity through an autonomic nervous system response (e.g. Rickard, 2004. Nantais & Schellenberg (1999) examined the influence of mood and arousal on the non-music benefits of music exposure. In that study, the ME was replicated. Similar findings were also noted after listening to a piece by Schubert. Novel to this study, the research incorporated a condition where participant listened to a short story prior to a cognitive task. In support of the arousal/mood account this stimulus resulted in a comparable effect on subsequent performance on a cognitive task. The study also highlighted preference as a possible moderator variable. Preferences for a particular stimulus (i.e. music vs. story) exaggerated the enhancement effect. It appears therefore that personal preference played a major role in the observed results and that music belongs to one of several types of pleasurable stimuli that lead to increases in arousal or mood.

These conflicting viewpoints are not necessarily incompatible. Using the precision of ERP methodology, the present experiment examined two components related to unconscious and conscious aspects of cognition in a group of classically trained and rock musicians. In addition, two listening conditions (rock vs. classical music) were presented to each group. This design enabled an examination of preference in the form of familiarity and experience with ones own music genre. In addition, the effect of classical music exposure could be examined across all musicians. The two components, the N2 and P3, have provided a wealth of information regarding normal and dysfunctional cognition (see Bashore & van der Molen, 1991 for a review) and are therefore particularly suited to the current investigation. If classical music were special, one would expect facilitation across participant groups and perhaps at the pre-attentive/unconscious stage of processing (e.g. N2). However, later ERPs are more amenable to conscious control. Therefore, own genre preference is more likely to impact on the P3 ERP.

2. Method

2.1. Participants

Sixteen participants (10 male) with a mean age of 32 years (range 18–58 years) completed the experiment. Five right-handed string musicians from the Orchestra for Scottish Opera and 3 right-handed string musicians from the Royal Scottish Academy of Music and Drama were recruited for the classically trained group. Eight right-handed contemporary (rock) guitar players from the Glasgow School of Modern Guitar were recruited for the rock musician group. There was no age difference between classical (mean age = 39 years) and rock (mean age = 33 years) groups; $t(14) = 0.8$, $p = .41$. Participants reported no history of neurological disease and reported normal hearing and vision. Participants were instructed to refrain from consuming drinks containing caffeine and/or glucose and from smoking one hour prior to the experiment. Each participant gave written consent to participate, which was approved by the Department of Psychology, Glasgow Caledonian University ethics committee.

2.2. Materials and procedure

Music presentation was by means of the Western music scale (major, minor, chromatic, modal). The classical music (CM) condition was Ludwig van Beethoven's 2nd *symphony*. The rock music (RM) condition was Steve Vai's instrumental track '*For the Love of God*'. The CM and RM conditions were presented at 50 db. Issues concerning licensing and copyright permission were addressed by the licensing manager for the rock musician Frank Zappa and his record label 'Rykodisc' i.e. N. Moran (personal communication, April, 2004), A standard 2 stimulus visual oddball paradigm was employed. Two stimuli were presented on a 15 in. computer monitor at regular intervals. The non-target frequent stimuli ($n = 200$) were green squares (150×150 pixels). The rare target stimuli ($n = 40$) were red circles (150×150 pixels). The frequent and rare stimuli were randomly presented during each block. Each block (classical vs. rock condition) was randomly presented to the participant. A trial consisted of a blank screen for 100 ms, stimulus presentation for 100 ms and finally a blank screen for 1600 ms. During this time the participants had to ignore non-target (frequent) stimuli and respond by pressing the 'space bar' on a standard computer keyboard when the target (rare) stimulus appeared.

2.3. Event-related potential recordings

Electroencephalograms were recorded from 62 channels using an electrode cap (Neuromedical supplies) based on the international 10–20 system. The montage included eight midline sites (FPZ; FZ; FCZ; CZ; CPZ; PZ; POZ; OZ), 27 sites over the left hemisphere (FP1; AF3; F1; F3; F5; F7; FC1; FC3; FC5; FT7; C1; C3; C5; T7; CP1; CP3; CP5; TP7; P1; P3; P5; P7; PO3; PO5; PO7; O1; CB1), and 27 sites over the right hemisphere (FP2; AF4; F1; F4; F6; F8; FC2; FC4; FC6; FT8; C2; C4; C6; T8; CP2; CP4; CP6; TP8; P2; P4; P6; P8; PO4; PO6; PO8; O2; CB2). Additional electrodes were placed on the left and right mastoid (impedance between left and right mastoids was kept below 2 kΩ). All EEG recordings were referenced to the linked mastoid processes. Inter-electrode impedance levels were kept below 5 kΩ. Horizontal-electrooculograms (HEOG) were recorded from electrodes placed at the outer canthi of each eye. To assess eye blink motion, separate electrodes were placed above and below the left eye to record the vertical-electrooculogram (VEOG). All signals were digitised at a rate of 500 per second with 801 points, thus giving a recording epoch of 1500 ms, beginning 100 ms prior to stimulus onset. To capture respectively the P3 and N2 components data were averaged in the 320–500 ms, and 250–300 ms time windows.

3. Results and discussion

The event-related potential analysis involved targeting the electrodes which have previously been found to elicit the N2 and P3 components (see for example Patel & Azzam, 2005 for review). Table 1 summarises the ERP data across listening condition and participant group whilst Table 2 summarises the behavioural data. No differences were observed between group or condition so these data are not discussed further.

Table 1
The N2 and P3 mean amplitudes (*SD*) for classical and rock musicians across listening condition and electrode site

Electrode	Condition	Group			
		N2		P3	
		Classical mean (*SD*)	Rock mean (*SD*)	Classical mean (*SD*)	Rock mean (*SD*)
Frontal	Classical	−2.80 (4.88)	−4.13 (5.31)	12.90 (3.72)	8.35 (5.88)
(Fz)	Rock	−0.81 (5.31)	−2.28 (5.30)	14.46 (4.65)	7.39 (5.17)
Central	Classical	−5.45 (6.80)	−4.25 (3.80)	17.11 (8.26)	14.21 (6.17)
(Cz)	Rock	−2.75 (6.98)	−2.66 (5.53)	18.64 (7.20)	13.39 (8.19)
Parietal	Classical	−1.30 (5.95)	−1.03 (3.62)	19.56 (9.95)	22.08 (8.12)
(Pz)	Rock	−0.30 (6.49)	−0.46 (3.03)	22.09 (8.13)	15.78 (5.64)

Table 2
Target stimuli mean reaction time and accuracy for classical and rock musicians across listening condition

Condition	Group			
	Reaction time (ms)		Accuracy (%)	
	Classical mean (*SD*)	Rock mean (*SD*)	Classical mean (*SD*)	Rock mean (*SD*)
Classical	372 (38)	355 (45)	100 (0)	100 (0)
Rock	353 (30)	362 (40)	98 (3)	100 (0)

Analyses of variance (ANOVA) were carried out on the N2 and P3 data displayed in Table 1. The difference between N2 amplitude was analysed in a 2 (group: classical vs. rock musicians) × 2 (condition: classical vs. rock music) × 3 (site: frontal vs. central vs. parietal) ANOVA. The main effect of condition demonstrated greater negativity during exposure to classical music ($F(1,14) = 6.4$, MSE = 9.8, $p < .05$). The main effect of site demonstrated greater negativity in the central than parietal site but no difference in negativity between frontal and central sites.

The difference between P3 amplitude across group and condition was analysed in a 2 (group: classical vs. rock musicians) × 2 (condition: classical vs. rock music) × 3 (site: frontal vs. central vs. parietal) ANOVA. The main effect of site demonstrated greater amplitude for more posterior electrodes ($F(2,28) = 19.4$, MSE = 25.9, $p < .01$). The interaction between condition and group demonstrated greater amplitude of the P3 for each group whilst listening to their own music genre ($F(1,14) = 3.9$, MSE = 12.3, $p = .07$). After 1 extreme value in the classical group was removed ($F(1,14) = 7.2$, MSE = 17.8, $p = .02$).

The ERP results gathered during the visual oddball task are highlighted in Fig. 1. Supporting Rauscher and colleagues' position, the N2 negativity was more pronounced in the classical condition indicating enhancement at the pre-attentive stage of processing across groups. Previous research suggests this component is related to automatic stimulus identification (Patel & Azzam, 2005). Taking the research further, less cognitive resources were engaged during the task for classical musicians exposed to classical music and rock musicians exposed to rock music. This is indexed by the reduction in P3 which is considered to reflect the maintenance in working memory of a stimulus when the mental representation of the stimulus context is updated (Polich, 2003). Here, the P3 was reduced whilst listening to the participant's music of choice indicating less cognitive resources being deployed for task completion. This finding suggests music preference and appreciation, rather than listening to classical music per se, is critical to the so-called the ME.

The most important aspect of the data related to the widely report ME was the finding of enhanced pre-attentive processes (N2 classical effect displayed in Fig. 1) during classical music for all participants. Con-

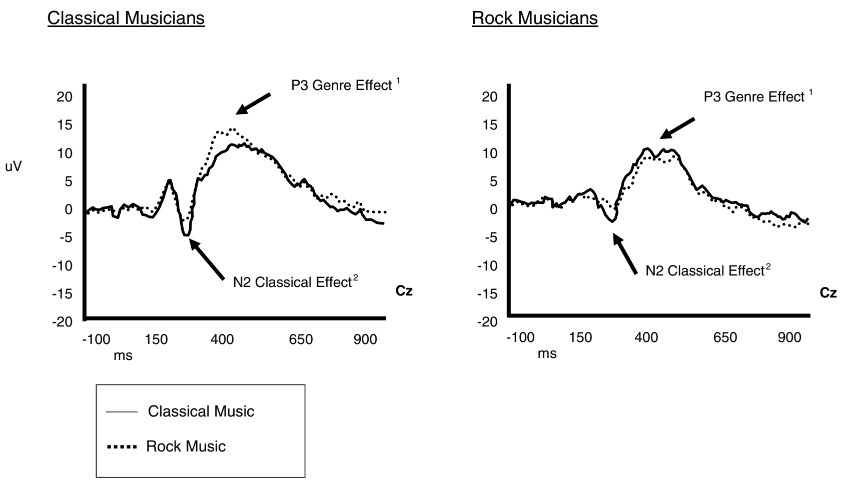

Fig. 1. Average difference waveforms (targets minus non-targets) for classical and rock musicians during exposure to either classical or rock music *(1) group × condition effect ($p = .02$) & (2) condition effect ($p = .03$).

sidering the Trion model of cortical organisation, it is not unreasonable to suggest that facilitation of neural firing patterns is restricted to a subset of cognitive processes during classical music exposure. This poses the question of which qualities of classical music are responsible for the enhancement? Although employing identical scale structures, marked differences in timbre, orchestration, harmony and modality within the Beethoven and the Vai pieces are evident. These key features of classical music might underlie fundamental changes in neural activity, whereas those effects related to preference (P3 genre effect displayed in Fig. 1) are mediated by mood, enjoyment, familiarity, or expertise. This notion clearly warrants further investigation.

In summary, access to classical music is likely to impinge upon unconscious processing, whereas appreciation of music is more related to conscious aspects of cognition. The intricacies of the established ME are clearly more complex than indicated by behavioural studies. Particularly noteworthy are the dissociable effects related to conscious and unconscious aspects of cognition and the finding of facilitation when exposed to contemporary music rather than classical music alone. Here we demonstrated classical music facilitation and musical preference for the same participants within one task. Further work using ERPs is warranted since behavioural measurements have proven insensitive in pinpointing the factors responsible for cognitive enhancement. Similarly, long-term non-music benefits associated with music training have yet to be established. Here differences in the length of music training between contemporary and classical musicians might be crucial. Further research into this aspect of music and human cognition is imperative.

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